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METEOROLOGY AND SEISMOLOGY IN CHINA

- USSR -

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long-range weather forecasting; climatology; physics of clouds and fogs; and research in artificial clouds. Here we shall dwell only on the problems of atmospheric circulation and long-range weather forecasting.

Modern synoptic methods were used to analyze both the status and features of circulation in East Asia and the physical nature of the fundamental synoptic processes over the territory of China. Also, certain activities were conducted with regard to the study of the fundamental laws of atmospheric circulation. The structure of the circulation in East Asia during various seasons was drafted on a preliminary basis. As of 1950 upper-air pressure maps and vertical cross sections of the atmosphere have been used for investigating the structure of circulation in East Asia and, as a result, for establishing numerous new facts. Thus, e.g., in 1950 it was discovered that during the winter period two branches of jet streams exist over China. Figs. 1 and 2 present two cross sections, for longitudes 75° E and 120° E for January, February, and March 1956. From these figures it can be seen that zonal circulation predominates over Asia during the winter period, in which connection the two jet-stream branches are expressed quite clearly: the northern branch lies at an altitude of 10-12 km, and the southern, upward of 12 km. But in the summer period the structure of circulation is different. Figs. 3 and 4 present two cross sections for longitudes 90° E and 120° E, for July and August 1956. During that period, zonal circulation also predominates in the zone north of latitude 30° N, and a jet-stream branch exists in the zone between latitudes 40° N and 45° N. South of latitude 30° N, in the lower layers of the atmosphere, the Indian southwesterly monsoons predominate, and in the upper ones -- tropical easterly currents. The zone between latitudes 30° N and 40° N is the transition zone of upper-air easterly and westerly winds, corresponding to the mean position of the subtropical crests on the continent during the summer period.

The question of seasonal variations in circulation over East Asia was more precisely clarified. It was found that the circulation there is characterized by explicit features which are reflected in the synoptic processes during the various seasons of the year. Moreover, during the transitional seasons /spring and autumn/ the variations in circulation are generally abrupt. Of special interest are the two transitional periods observable annually at the end of May and beginning of June and in mid-October. During these two periods the upper-air circulation changes drastically not only in East Asia but also throughout the entire Northern

Hemisphere. The discovery of these facts has made it possible to penetrate even more deeply into the nature of both the synoptic processes in Southeast Asia and the general circulation in East Asia, which to a definite extent assists the long-range forecasting of weather in China.

The principal factors active in altering the weather in the country have been tentatively uncovered. Thus, e.g., in China, a cold wave and frosts encompassing large areas are particularly dangerous weather phenomena, and the prediction of summer showers and typhoons is the fundamental problem of forecasting.

In the last 10 years considerable research has been done in these dangerous synoptic phenomena and in the methods of forecasting them.

The Influence of the Tibetan Plateau on Weather

In height and in area the Tibetan Plateau is the largest in the world, and hence, indisputably, it should exert a major influence on both the climate and weather in China and the general atmospheric circulation over the entire Northern Hemisphere. Prior to the country's liberation only one meteorological station, conducting observations for less than three years, had existed in this plateau. At present the station network has been considerably expanded. The Institute of Geophysics, Academy of Sciences CPR, has assigned a large team of researchers to the study of the meteorology of the Tibetan Plateau. Their activities have resulted in the publication of the book "The Meteorology of the Tibetan Plateau," which generalizes the studies of the effect of this plateau on atmospheric circulation in East Asia.

It was found that the changes in weather in the various seasons in the Tibetan Plateau are mainly conditioned by the migrating synoptic systems arriving mostly from Central Asia and also from Siberia. In the winter not only a cold front but also intense cold waves often pass over this plateau. In the summer, sometimes there intrude Indian southwesterly monsoons forming a zone of the convergence of east-west air currents which gives birth to strong thunderstorms -- sometimes even accompanied by hail. Moreover, in the summer period, over the Tibetan Plateau there often exist migrating closed upper-air anticylones constituting a part of the dynamic anticyclones to the south of the zone of westerly winds, and in the vernal period there may appear "cut-off" cold eddies. It was found that the formation of such cold eddies is to a definite extent related to the blocking in the zone of westerly wind north of the Tibetan Plateau.

As a consequence of the complexity of their topographical conditions, during the predominance of a single synoptic situation the weather differs in various places on the Tibetan Plateau. To cope with the difficulties involved is an analysis of the synoptic situation on this plateau, we have proposed a number of new methods which have proved to be extremely effective and are of major importance to the weather service.

As can be seen from the mean monthly upper-air charts for the winter period, the jet-stream branches always border both sides of the Tibetan Plateau during that period. Previously we had assumed that these two branches form under the dynamic action of the plateau itself. But this opinion was not corroborated by a large number of subsequent observations. In effect, these branches are independent of the plateau; they can be tracked throughout the entire Northern Hemisphere. Moreover, in winter the axis of upper-air jet streams is often observed over the plateau. Of late it was established that that axis appears and disappears once every seven to 10 days, which is related to the formation, movement, and waning of disturbances in the zone of westerly winds. On reaching the western part of the plateau the strong long-wave troughs are split into two parts: the northern one proceeds eastward, weakening rapidly, while the southern one proceeds in the same direction but across the plateau. Consequently, long-wave troughs rarely pass or stop over the western and central parts of China. This is a result of the inhibiting effect of the Tibetan Plateau on the upper-air troughs. This conclusion has already been confirmed by numerous observations.

In connection with the inhibiting effect of the plateau, the cyclones over China's territory are far from being as active as over the other areas of the moderate belt.

Formerly we had assumed that the low-pressure zones arriving from Central Asia cannot intersect the plateau and move on farther east. This opinion, likewise, has not been confirmed by subsequent observations. It was found that in winter, on the average, six or seven upper-air troughs traverse the plateau, and an overwhelming majority of these troughs is related to the weakened cyclones from Central Asia. On reaching the eastern part of China, these troughs completely weaken. However, there also occur individual large troughs which, on reaching Central China and spreading there on account of cold air behind them, can, in that zone, regenerate themselves and cause the formation and development of ground cyclones.

Fundamental Theories of Atmospheric Circulation

The causes of the formation of an averaged scheme of atmospheric circulation were investigated. For this purpose, the method of small disturbances was used to compute the mean topography in the baroclinic* atmosphere for Europe, Asia, and the Western Hemisphere on the 500-millibar surface for January, on taking into account both the effect of the natural relief and the effect of the natural field of heat distribution. The calculations yielded satisfactory results. Moreover, the investigations were extended to the effect of large mountane massifs on disturbances of a finite amplitude in the zone of westerly winds in a three-dimensional baroclinic atmosphere. Fig. 5 presents a chart of mean values for the Northern Hemisphere in winter for the 700-millibar surface, as compiled on the basis of calculations. The chart shows that the calculated positions of troughs and crests correspond on the whole with their natural positions.

Interesting results were yielded by studies of the equilibrium of the various physucal parameters of the atmosphere (angular momentum, kinetic energy, heat, etc.). In the studies of the equilibrium of angular momentum a disputed problem was that of the role of meridional circulation, in particular of the Hadley Ring (Hadley Cell), in the low latitudes. To solve this problem, the effect of the Hadley Ring was initially demonstrated on the basis of observations. Fig. 6, which presents the averaged situation in the cross section over the meridian in 1950, shows clearly longitudinal circulation. This was followed by the commencement of research on the problem of the equilibrium of angular momentum, inclusive of the cyclic transport of angular momentum and its exchange between the atmosphere and the Earth. The studies of the kinetic energy of the atmosphere were initiated by calculating, on the basis of observations, the content of that energy and the balance of mean kinetic energy, and were then followed by an examination of the processes of the equilibrium of kinetic energy. Also under study has been the problem of the equilibrium of perceptible heat $C_p \rho T$ (C_p is specific heat at constant pressure, ρ is density, and T is absolute temperature).

The researches were also extended to the relationship between the above-mentioned physical processes and certain important circulation phenomena (zone of easterly winds, zone of westerly winds, mean meridional circulation, large-scale disturbances in the form of troughs, crests, etc.). In our

*In a baroclinic medium density depends on the pressure and temperature of the air.

opinion, an essential role is played by the large-scale disturbances, which give birth to the interaction between, and interrelationship of, the given phenomena.

The aperiodic changes in atmospheric circulation constitute the principal object of study for the purposes of long-range forecasting with small advance notice, i.e., forecasting for several days in advance. Such changes manifest themselves in the birth and disappearance and forward and backward movements of large-scale disturbance in the atmosphere. Upon variations in these disturbances the equilibrium processes of the afore-mentioned physical parameters are correspondingly diagonally opposite. Thus, e.g., during the period of the development of disturbances (the period with a low index of circulation) in the middle latitudes a certain amount of heat is transported northward and the potential energy of the disturbances changes to kinetic energy, while during the period of the decline of disturbances (the period with a high index of circulation) the heat in these same latitudes is transported southward and the kinetic energy changes to potential energy. We assume that the equilibrium processes of atmospheric circulation consists mainly of these two mutually opposing processes.

All these researches have been generalized in the monograph on "Certain Fundamental Problems of Atmospheric Circulation," issued by the Institute of Geophysics, Academy of Sciences CPR, in 1958.

During the development of the methods of long-range weather forecasting, on the basis of the postulates of the school of B.P. Mul'tanovskiy, the specific features of natural synoptic periods in East Asia were brought under investigation. On the basis of the obtained results, the Central Meteorological Station compiled long-range forecasts for three to 15 days. Upon completing the classification of the natural synoptic periods in East Asia in the past 10 years, we commenced studies of the rhythm of these periods; thereby, we ascertained several dozen useful rules for finding this rhythm. For instance, all zonal periods display an explicit rhythm of 105 ± 2 days; at the same time, we discovered that during various seasons every period of this type is characterized by a distinct law of recurrence. On the basis of the results of these studies, the recurrability of natural synoptic periods can be predicted for three months in advance. In addition, the peculiarities of weather in China during various periods were investigated in detail. The given method was used to compile long-range forecasts for the fourth quarter of 1958 and the first quarter of 1959; the forecasts of several intrusions of cold air proved to be relatively accurate.

Seismology

The seismic zones of China are very extensive. In the western montane areas and in the regions surrounding the Island of Taiwan violent earthquakes are a frequent occurrence. In the densely populated central areas destructive earthquakes also occur from time to time. According to the information provided by history, in 1556 a large earthquake whose destructive effect spread over a territory of more than a million square kilometers occurred on the northern slopes of the Tsing Ling Mountain Range, east of the city of Sian. As a result, over 830,000 inhabitants were killed or injured. In 1920, a violent earthquake in the Liupan Shan, in the eastern part of Kansu Province, devastated several cities took a toll of more than 200,000 human lives. This was one of the world's most violent earthquakes. In the 17th and 18th centuries, Peiping was twice subjected to destruction by earthquakes with a force of seven and eight points. In addition, in the Northeast and in the southwestern parts (close to Burma) deep-focus and medium-focus earthquakes have been recorded. Fig. 7 presents a map of the epicenters of strong earthquakes, compiled on the basis of historical records for the period from 1,000 B.C. to 1955.

After the country's liberation, in connection with the development of the construction of socialism, it was necessary to undertake rational anti-seismic measures when erecting numerous industrial structures in the seismic regions. This required a correct assessment of the seismic danger in various construction regions. Because of the insufficiency of instrument observations, this assessment was made mainly on the basis of historical statistical records. To bring a systematic and properly classified order into these data, China's historians examined over 8,000 diverse literature sources containing this or that information about earthquakes (official and other chronicles, local "historical-geographical descriptions," notes, sketches, poems, articles, archives of the imperial court, etc.). This resulted in the publication of the "Chronological Tables of Seismic Data on China," in which over 15,000 descriptions of past earthquakes are collected.

The seismologists of the Institute of Geophysics, Academy of Sciences CPR, have analyzed and systematized these historical data and, on complementing them with the materials of modern instrument observations, compiled "The Catalog of Chinese Earthquakes." The first volume of the catalog, which encompasses mainly 1,180 large earthquakes in the period from 1,189 B.C. till 1955, provides information on the beginning

instant of the tremors, the locus of epicenters, estimated intensity, and principal phenomena of the devastation. The second volume has been compiled in district-by-district form and it is designed as a reference manual for local construction.

To verify the historical information and to obtain new experimental information, several omnilateral expeditions were organized: consisting of seismologists, geologists, architects, designers and historians; these expeditions conducted field research in the principal construction regions. This yielded abundant data characterizing the destruction of various types of structures under the action of earthquakes (6-12 points) in various areas of China. This is of exceptional importance in assessing the force of earthquakes. Chinese construction projects differ both in structure and in execution and building materials from those to which the seismic scales widespread in other countries are applicable. Therefore, difficulties are often encountered and errors are easily committed when the foreign seismic scales are applied. It would be necessary to devise a seismic scale appropriate to the concrete conditions of China. On the basis of an analysis of numerous macroseismic investigations and a study of the seismic scales applied in the other countries, in 1956, a seismic scale based on the indexes characteristic for China was devised with the participation of a Soviet specialist, S.V. Medvedev.

To provide reference material for construction work, and also to further the planning of the studies of regional seismicity, it was necessary to compile a map of seismic regionalization. For this purpose, considering the lack of omnilateral seismological studies, it was provisionally proposed (just as in the USSR) that earthquakes of a single force may recur at the same spot, and that seismicity may be identical in regions having identical geological conditions. Following this principle, and utilizing all the available useful historical and instrument data and considering the general outline of the geological conditions of the appearance of earthquakes, we have, with the participation of a Soviet specialist -- Professor G.P. Gorshkov -- compiled a scheme of seismic regionalization of China's territory. Although this scheme has been compiled at a time when a number of fundamental theoretical problems still remain unsolved, and although the utilized data are insufficient, it will undoubtedly serve as an important document for investigating seismicity and geotectonics, and also as a useful reference material for the planning of construction.

The work on microseismic regionalization, which is

being carried out for the regions with extensive construction, on the basis of the utilization of the earthquake-force scale and the conditions of the soils, underground waters and geomorphology, is of practical importance. The conclusions it yields are utilized in Peiping and other localities, and they will be applied in industrial construction in other places.

The development of instruments is one of the crucial aspects of the development of seismology. Prior to 1956 the Chinese seismic stations had used principally domestic instruments. However, the sojourn of the Soviet seismological experts, Professors D.P. Kirnos and D.A. Kharin, was extremely conductive to the development of new seismic instrumentation in China, and the use of standard Soviet instruments and the utilization of their designs in new instruments have rapidly elevated the level of seismic observations. In connection with the peculiarities of local earthquakes in China, we need highly sensitive seismographs for recording weak earthquakes which should be distinguished by their structural strength, stable quality, simplicity of operation and convenience of transport. For this purpose, two types of such seismographs, with recording on sooted /"zuKopchennaya by Maga"/ paper and with electronic amplification, have been developed. In the course of their laboratory tests these instruments have displayed good qualities, and shortly they will be installed in many seismic stations. At present, an inclinometer with optical recording is being developed experimentally. Moreover, horizontal seismographs with mechanical recording have been designed and subsequently utilized for recording medium-force earthquakes.

On the basis of available data, a partial study of the intensity of earthquakes in China had been conducted. For this purpose, 33 earthquakes from the period between 1906 and 1955 -- for which macroseismic and instrument-observation data exist -- were processed.

Our successes and achievements are closely tied to the selfless assistance by the USSR. The delegation of the Academy of Sciences CPR to the USSR in 1953 and the delegation of the Academy of Sciences USSR to the CPR in 1955 had laid, by their friendly mutual visits, the foundations for fruitful mutual collaboration. The signing of the Agreement on the Joint Conduct of Principal Researches in the Field of Science and Technology in 1958 had unlocked still broader prospects for an omnilateral and close scientific collaboration between both countries. Soviet specialists have not only provided the Institute of Geophysics, Academy of Sciences CPR, with considerable assistance in drafting its 12-Year Plan of the Development of Science and in rearing new cadres but they

also have participated vigorously in various activities of the Institute, especially in geophysical prospecting. The Institute of the Physics of the Earth imeni O. Yu. Shmidt, Academy of Sciences USSR, the Institute of the Physics of the Atmosphere, Academy of Sciences USSR, the Institute of Applied Geophysics, Academy of Sciences USSR, and the Institute of Building Materials and Structures under the Ministry of Construction Armenian SSR, have opportunely shared with us the results of their researches, and have presented blueprints and models of new instruments as well. The understanding between the two academies of sciences as to the joint conduct of scientific research in the field of geophysics is to a still greater extent conductive to mutual visits and exchange of experience between the geophysicists of both countries. Now the scientists of China are in direct contact with the geophysicists of the Academy of Sciences USSR, academies of sciences of the Armenian, Georgian, Tadzhik, Uzbek, Kazakh and Kirgiz union republics, as well as with scientists working in Soviet industry.

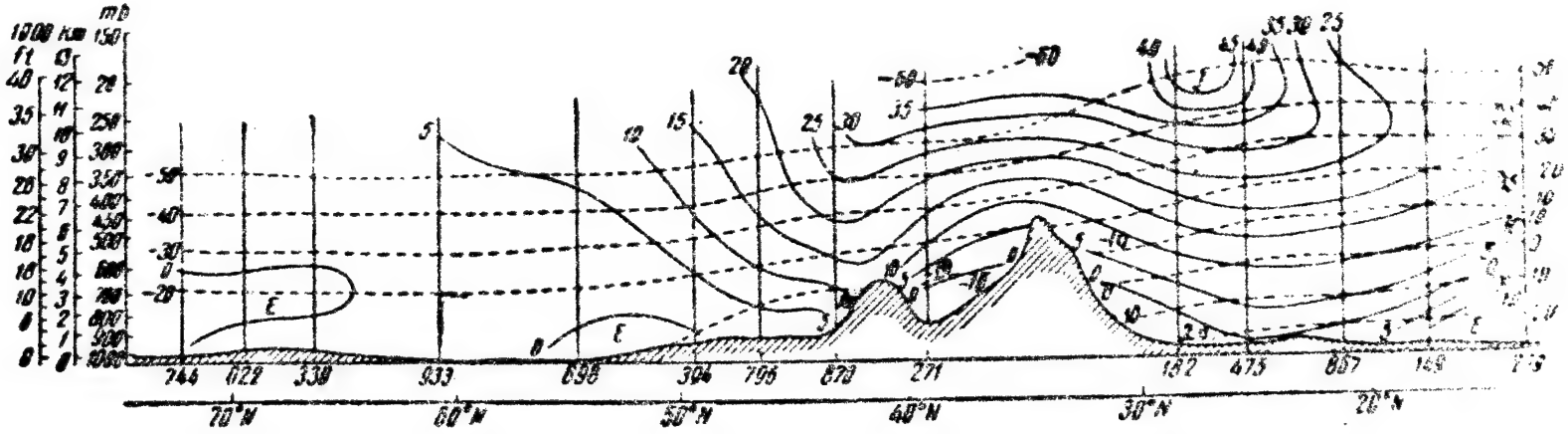


Fig. 1. Mean Cross Section for Longitude 75° E (Solid line denotes velocity of the geostrophic westerly wind in meters/second, and broken line -- the isotherms).

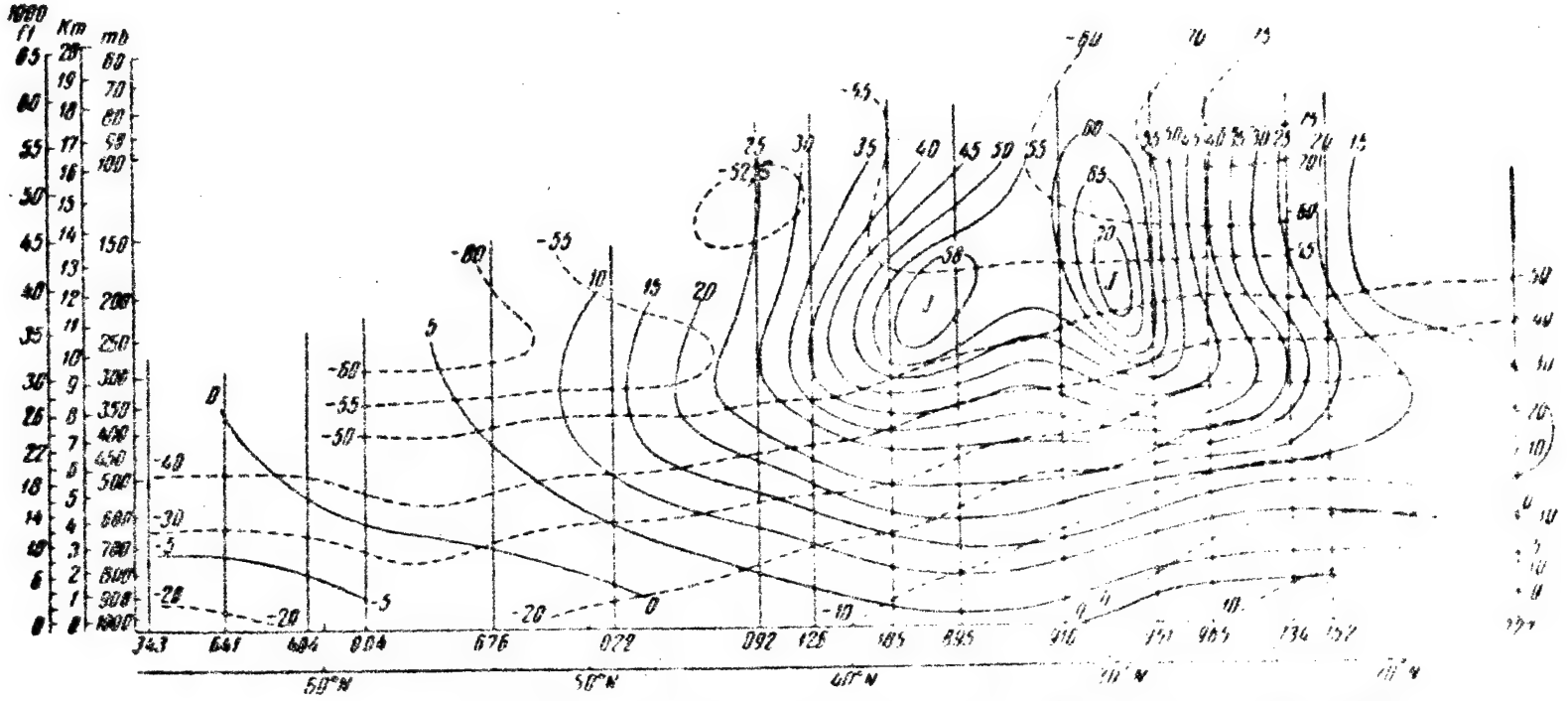


Fig. 2. Mean Cross Section for Longitude 120° E (Solid line denotes velocity of the geostrophic easterly wind in meters/second, and broken line -- the isotherms).

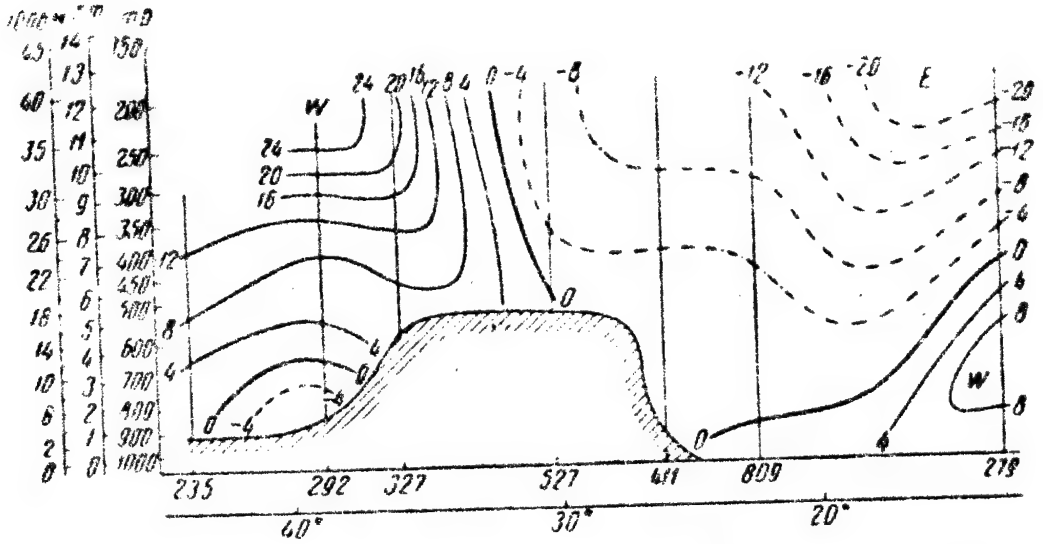


Fig. 3. Velocity of Zonal Natural Wind for Longitude 90° E in July and August 1956.

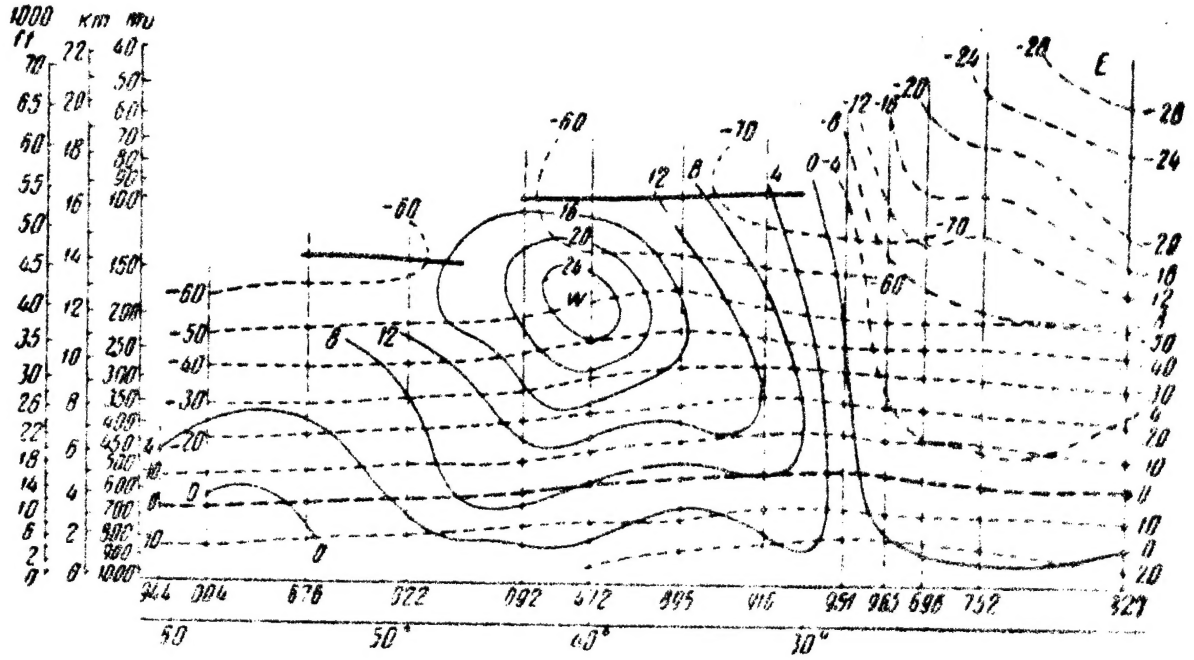


Fig. 4. Velocity of Zonal Wind in meters/second and Temperature (°C are denoted by broken line) for Longitude 120° E in July and August 1956.

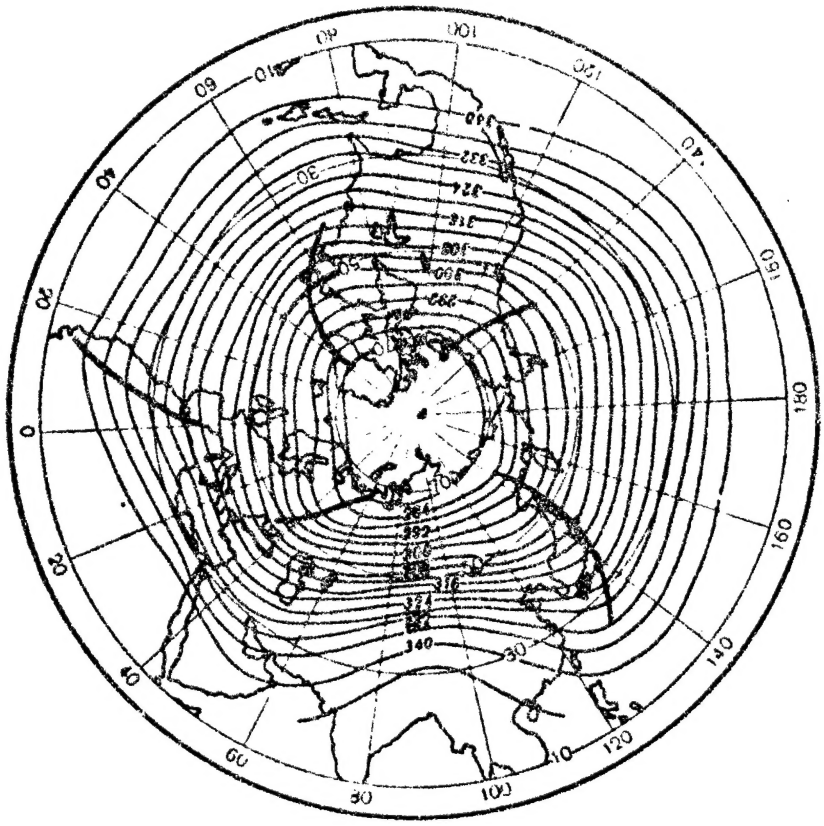


Fig. 5. Isobaric Chart for the 700-Millibar Surface, Compiled on the Basis of Calculations Taking Account of Disturbances by the Tibetan Plateau and Rocky Mountains.

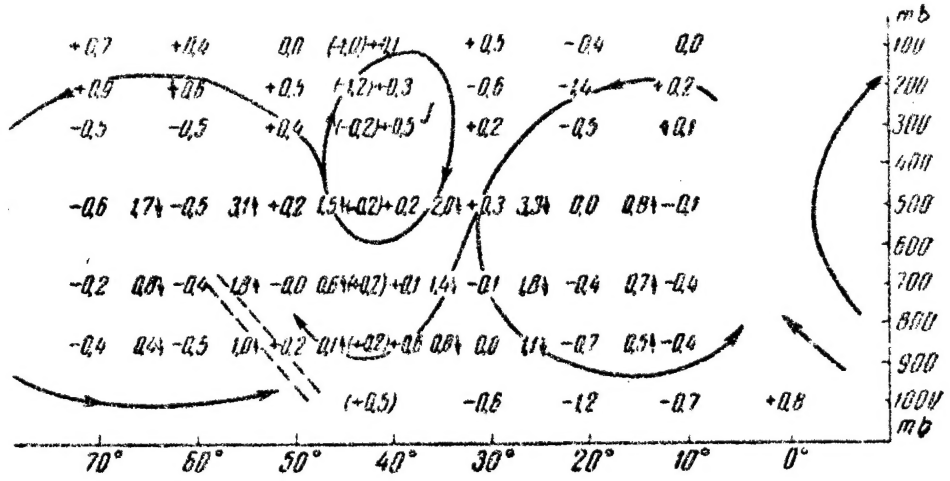
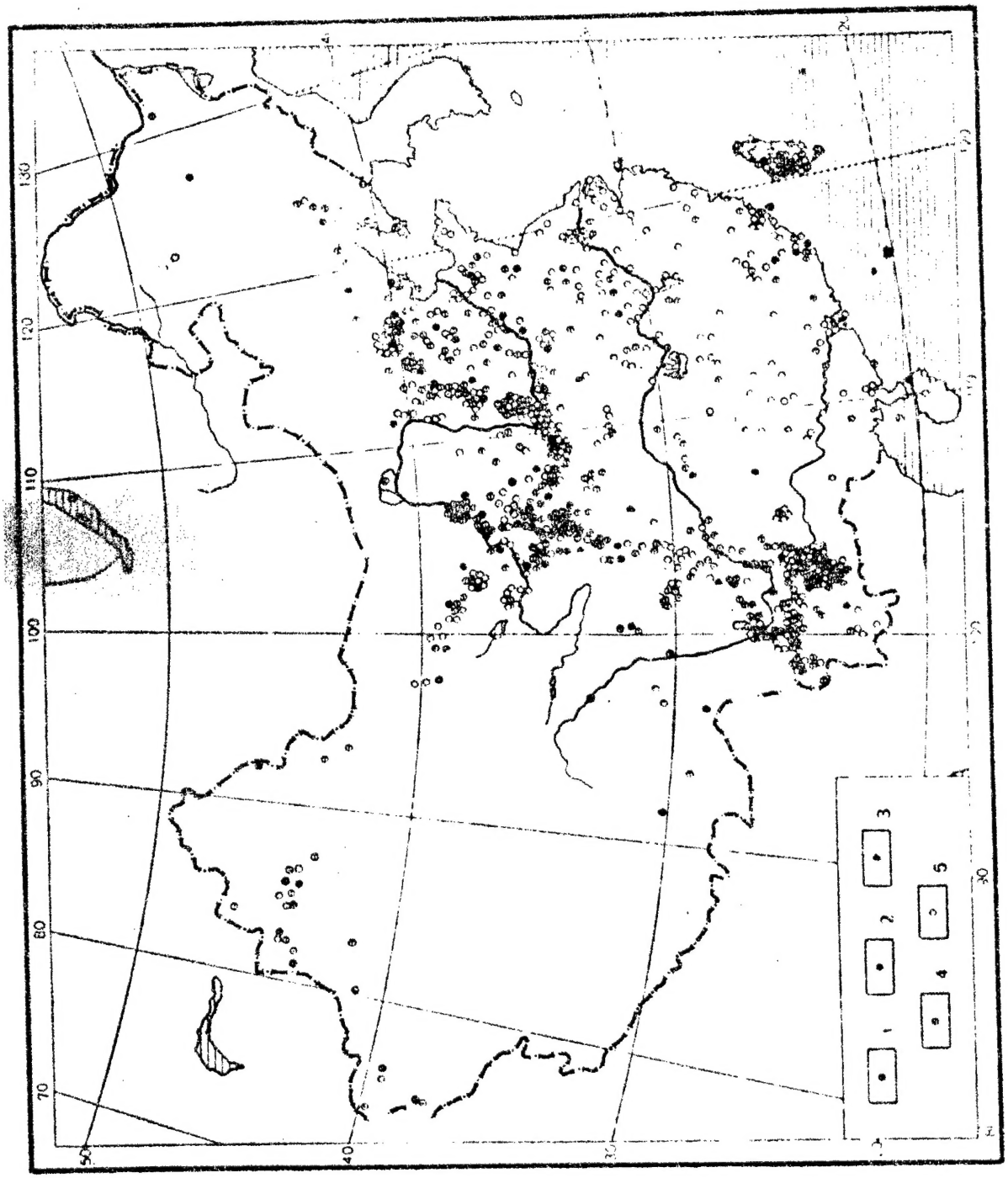


Fig. 6. Mean Annual Meridional Circulation in the Northern Hemisphere in 1950 and Mean Annual Situation of the Westerly Jet Streams; the double broken line refers to the mean position of fronts.

Fig. 7. Map of the Epicenters of Strong Earthquakes According to Historical Records for the Period from 1,000 BC to 1955
1. X points; 2. IX points; 3. VIII points; 4. VII points; 5. VI points.



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